

Claims:

1. A method for plating metal onto a substrate, comprising:
positioning the substrate in a catholyte solution contained in a catholyte chamber of a plating cell, the catholyte solution comprising:
an acid source at a concentration of between about 5 g/L and about 15 g/L;
a copper source at a concentration of between about 0.8M and about 0.9M; and
chlorine ions at a concentration of between about 25 ppm and about and about 75 ppm; and
applying a plating bias between the substrate and an anode positioned in an anolyte chamber of the plating cell, the anolyte chamber being separated from the catholyte chamber by an ionic membrane and being supplied with an anolyte solution comprising a copper source having a concentration of greater than about 51 g/L.
2. The method of claim 1, wherein the catholyte solution further comprises:
a leveler at a concentration of between about 2 mL/L and about 3 mL/L;
a suppressor at a concentration of between about 2 mL/L and about 3 mL/L;
and
an accelerator at a concentration of between about 5.5 mL/L and about 8 mL/L.
3. The method of claim 2, wherein the suppressor comprises at least one of ethylene oxide and propylene oxide.
4. The method of claim 2, wherein the accelerator comprises sulfo propyldisulfide.
5. The method of claim 1, wherein the anolyte has a pH of between about 2 and about 4.8.

6. The method of claim 5, wherein the anolyte comprises a copper II salt having a concentration of copper ions of between about 0.1M and about 2M.
7. The method of claim 6, wherein the copper II salt comprises at least one of copper sulfate, copper sulfonate, copper chloride, copper nitrate, and blends thereof.
8. The method of claim 5, wherein the anolyte provides a copper transport of copper ions through the ionic membrane of between about 90% and about 100%.
9. The method of claim 1, wherein the anode comprises at least one of a copper anode and a platinum anode.
10. A method for plating copper into features formed on a semiconductor substrate, comprising:
 - positioning the substrate in a plating cell, wherein the plating cell comprises:
 - a catholyte volume containing a catholyte solution;
 - an anolyte volume containing an anolyte solution;
 - an ionic membrane positioned to separate the anolyte volume from the catholyte volume; and
 - an anode positioned in the anolyte volume;
 - applying a plating bias between the anode and the substrate;
 - plating copper ions onto the substrate from the catholyte solution; and
 - replenishing the copper ions plated onto the substrate from the catholyte solution with copper ions transported from the anolyte solution via the ionic membrane, wherein the anolyte solution has a copper concentration of greater than about 51 g/L.
11. The method of claim 10, wherein the copper concentration is supplied by copper sulfate pentahydrate having a molarity of between about 0.8M and about 0.9M.

12. The method of claim 11, wherein the anolyte has a pH of between about 2 and 4.8.
13. The method of claim 10, wherein the plating cell further comprises a diffusion member positioned between an upper surface of the ionic membrane and the substrate.
14. The method of claim 13, wherein the diffusion member comprises a porous ceramic disk.
15. The method of claim 10, wherein the ionic membrane comprises a membrane having a fluorized polymer matrix.
16. The method of claim 10, wherein the ionic membrane comprises a membrane having a polydivinylbenzol matrix.
17. The method of claim 12, wherein the catholyte solution comprises:
acid at a concentration of between about 5 g/L and about 15 g/L;
copper at a concentration of between about 0.8M and about 0.9M; and
chlorine ions at a concentration of between about 25 ppm and about and about 75 ppm.
18. The method of claim 17, wherein the catholyte further comprises:
a leveler at a concentration of between about 2 mL/L and about 3 mL/L;
a suppressor at a concentration of between about 2 mL/L and about 3 mL/L;
and
an accelerator at a concentration of between about 5 mL/L and about 8 mL/L.
19. A method for electrochemically plating copper onto features of a semiconductor substrate, comprising:

positioning the substrate in a plating cell having a catholyte solution volume, an anolyte solution volume, and an ionic membrane separating catholyte solution volume from the anolyte solution volume;

contacting the substrate with a catholyte solution;

applying an electrical bias between the substrate and an anode positioned in the anolyte volume, the electrical bias being sufficient to plate copper ions from the catholyte solution onto the substrate; and

replenishing copper ions plated from the catholyte solution via transfer of copper ions from the anolyte solution through the ionic membrane to the catholyte solution, the anolyte solution having a pH of between about 2 and about 4.8 and a copper ion concentration of between about 0.1M and about 2M.

20. The method of claim 19, wherein the copper ion concentration in the anolyte comprises between about 51 g/L and about 60 g/L of copper metal to the anolyte.

21. The method of claim 19, wherein the anolyte provides a copper transport of copper ions through the ionic membrane of between about 90% and about 100%.

22. The method of claim 19, wherein the catholyte solution volume comprises:
an acid source at a concentration of between about 5 g/L and about 15 g/L;
a copper source at a concentration of between about 0.8M and about 0.9M;
and
chlorine ions at a concentration of between about 25 ppm and about and about 75 ppm.

23. The method of claim 22, wherein the catholyte further comprises:
a leveler at a concentration of between about 2 mL/L and about 4 mL/L;
a suppressor at a concentration of between about 1.5 mL/L and about 3 mL/L; and
an accelerator at a concentration of between about 5.5 mL/L and about 8 mL/L.

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24. The method of claim 23, wherein the anode comprises at least one of a copper anode and a platinum anode.

25. A method for plating copper onto a substrate, comprising:

positioning the substrate in a catholyte plating solution contained in a catholyte chamber of a plating cell, the catholyte plating solution comprising:

an acid source at a concentration of between about 5 g/L and about 15 g/L;

a copper source at a concentration of between about 0.5M and about 1.0M; and

chlorine ions at a concentration of between about 25 ppm and about and about 75 ppm; and

applying a plating bias between the substrate and an anode positioned in an anolyte chamber of the plating cell, the anolyte chamber being separated from the catholyte chamber by an ionic membrane.

26. The method of claim 25, wherein the anolyte comprises a copper source having a concentration of greater than about 51 g/L.

27. The method of claim 26, wherein the anolyte has a pH of between about 2 and about 4.8.

28. The method of claim 26, wherein the ionic membrane comprises a membrane having a polydivinylbenzol matrix.